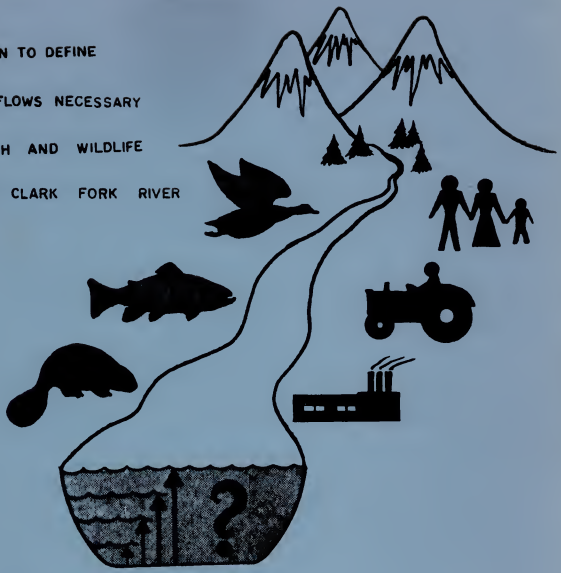
AN INVESTIGATION TO DEFINE MINIMUM STREAM FLOWS NECESSARY TO SUSTAIN THE FISH AND WILDLIFE RESOURCES OF THE UPPER CLARK FORK RIVER

Eutrophication-Related Influences



Baseline Nutrient, Diel Dissolved Oxygen and Algal Accrual Studies during 1976-77 and a Review of Previous Investigations

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I. INTRODUCTION

During the summers of 1976 and 1977 the Montana Department of Fish & Game conducted diel dissolved oxygen and periphyton productivity studies in the Clark Fork River between Deer Lodge and Huson, Montana. During the summer of 1976 diel dissolved oxygen was monitored only once; however, during the summer of 1977 it was monitored on 4 occasions. Additionally, during the summer of 1977, water samples were collected at six mainstem stations on four dates for common ion and nutrient analyses. Artificial substrates, used to measure periphyton production, were installed and sampled periodically at these same stations. Also, one water sampling run, consisting of twelve stations, was conducted from Deer Lodge to Thompson Falls. Included in this run were analyses for nutrients, common ions and seven heavy metals per station.

The ultimate goal of this study is to determine the correlation between decreased water quantity and quality and relative increases in algal production with subsequent nighttime "sags" of dissolved oxygen. Such predictive information will be formulated after the collection and study of additional data. The data herein, including a review of information from previous studies by other agencies on the Clark Fork River, comprises an initial, baseline report.

Early morning dissolved oxygen levels dipped quite low in the upper Clark Fork River during the July 1977 sampling run. August dissolved oxygen sags were not quite so severe, presumably a result of unseasonably cold and rainy weather.

Periphyton productivity measurements were plagued by vandalism. However, the scattered data that was obtained generally demonstrated that increased

periphyton production was correlated with higher concentrations of macro-nutrients such as phosphate and nitrate.

II. METHODS

A. Water Quality Sampling

The following six mainstem stations were sampled once in late July, twice in August and once in mid September for common ion and nutrient analyses:

STATION	LEGAL DESCRIPTION
Deer Lodge	T8N R9W Sec. 3
Gold Creek	T10N R11W Sec. 26
Bonita	T11N R16W Sec. 10
Turah	T12N R18W Sec. 2
Reserve St. (Missoula)	T13N R19W Sec. 18
* Grove St. (Missoula)	T13N R19W Sec. 19
Huson	T15N R22W Sec. 26

* The Grove Street station was substituted for Reserve Street station starting with the 2nd August sampling run. The Grove Street station was approximately 1000 feet (300 meters) below the City of Missoula waste treatment plant.

In mid September the following additional stations were sampled along with the previously mentioned 6 stations for common ions, nutrients and total recoverable metals:

STATION	LEGAL DESCRIPTION
Blackfoot River above Bonner	T13N R18W Sec. 22
Bitterroot River at Missoula	T13N R20W Sec. 26
Clark Fork at Superior	T17N R26W Sec. 34
Clark Fork above Paradise	T18N R25W Sec. 4
Flathead River below Perma	T18N R24W Sec. 6
Clark Fork at Thompson Falls	T21N R29W Sec. 8

All chemical analyses were performed by the chemistry laboratory of the Department of Health and Environmental Sciences in Helena, Montana. A description of the study area and sampling stations is displayed in Figure 1.

B. Diel Dissolved Oxygen and Temperature Sampling

Diel dissolved oxygen and temperature measurements were made at selected mainstem stations once in July of 1976 and 1977, twice in August of 1977 and once in September of 1977. These measurements were obtained by teaming a Uniloc dissolved oxygen analyser/recorder with a Taylor seven-day recording thermograph. The dissolved oxygen analysers were periodically calibrated with Iodometric titrations (APHA 1975).

C. Periphyton (Artificial Substrate) Sampling

Artificial substrates, consisting of transparent slide trays holding 8 microscope slides suspended below the water surface by floating supports (available from Design Alliance, Cincinatti, Ohio), were placed at the 6 mainstem stations several times during the summer of 1977. As was mentioned earlier, many of these artificial substrates were lost to vandalism. Samples that were collected were preserved for biomass accrual determinations as dry and ash weights and as chlorophyll-A expressed in $mg/M^2/day$, or net productivity (APHA 1975).

III. RESULTS & DISCUSSION

The data from the summers of 1976 and 1977 are only baseline in nature and are not, at this time, predictive. It is anticipated that additional data collection methods, including algal assays, will be utilized in preceeding years. However, some important trends in the data collected thus far can be noted.

A. Water Quality Sampling

Summertime macronutrient concentrations are highest in the upper river in the vicinity of Deer Lodge. Nutrient concentrations gradually decreased

Figure 1 CLARK FORK AND TRIBUTARIES

downstream to very low levels just above Missoula. An increase in nutrient concentrations was obvious just below Missoula while concentrations 60 miles (95 Km) below Missoula at Superior were very low and remained low to Thompson Falls. The samples from the three major tributaries, (The Blackfoot, Bitterroot and Flathead Rivers) were conspicuously low in dissolved salts and nutrients. Only the Bitterroot had detectable levels of orthophosphate or nitrate. Water Quality data is displayed in Tables 1 through 4.

Additionally, a recent review of records at the Montana Department of Health and Environmental Sciences, Water Quality Bureau, revealed that although a considerable amount of water quality data has been collected during recent years in the upper Clark Fork River, the majority of this data has been collected above Gold Creek. The primary emphasis during most of the past collections, in turn, has been towards heavy metal or common ion analyses; very little nutrient information has been accumulated during federal, state or private surveys.

One notable exception is a series of samples collected by the U.S. Geological Survey from 1969-1973. From 1969-1971, monthly samples were collected at five stations - Deer Lodge, Garrison, above Missoula, Alberton, and Thompson Falls. In the remaining two years, all of these stations except Thompson Falls were discontinued, but Galen (above Deer Lodge) and Drummond were added along with the Bitterroot River at Missoula and the Flathead River at Perma. The sampling frequency was also reduced in these latter two years, but the records are still worthy enough to serve as reliable background information. The USGS data for these four years is therefore presented by station in Appendices 1-7.

Another informative set of data was collected by the U.S. Environmental Protection Agency from August 19-23, 1974 (EPA 1975). Ten mainstem stations

TABLE 1

WATER QUALITY DATA FOR 6 STATIONS
ON THE CLARK FORK RIVER 7-21-77

STATION	HCO_3	CO_3	SO_4	pH	COND.	HARD	ALKA.	TSS	TP	OPO_4	NO_2NO_3
DEER LODGE	201.	0.	232.	7.9	763		165		.078	.060	.11
GOLD CREEK	206.	0.	155.	8.2	639		169		.056	.045	.03
BONITA	222.	0.	151.	8.0	639		182		.021	.010	.07
TURAH	157.	0.	82.	8.2	403		129		.011	.004	.04
RESERVE ST. MISSOULA	155.	0.	43.0	8.2	329		127		.010	.003	.03
HUSON	143.	0.	32.0	8.1	309		122		.023	.017	.07

TABLE 2

WATER QUALITY DATA FOR 6 STATIONS ON THE
CLARK FORK RIVER 9-4-77

STATION	Ca	Mg	Na	HCO_3	CO_3	SO_4	pH	COND.	HARD	ALKA.	TSS	TP	OPO_4	NO_2NO_3
DEER LODGE	105.	20.7	27.9	306.	0.	227	8.2	757.6	348	251		.091	.055	.10
GOLD CREEK	94.	9.7	23.0	202.	4.	164	8.3	666.7	276	172		.063	.035	.01
BONITA	88.	14.3	17.9	212.	0.	14.1	8.2	648.0	279	174		.039	.016	.05
TURAH	56.	14.6	10.5	155.	4.	86.	8.4	420.5	200	133		.021	.009	.04
RESERVE ST. MISSOULA	45.5	13.9	7.20	159.	0.	44.6	8.2	337.5	171	130		.024	.008	.03
HUSON	38.1	11.8	11.0	157.	0.	29.4	7.8	319.1	144	129		.049	.019	.05

TABLE 3

WATER QUALITY DATA FOR 6 STATIONS ON THE CLARK FORK RIVER 8-18-77

STATION	Ca	Mg	Na	HCO_3	CO_3	SO_4	pH	COND.	HARD	ALKA.	TSS	TP	OPO_4	NO_2NO_3
DEER LODGE	65.	31.5	28.2	167.	8.	167.	8.5	753.	292	150	5.8	.072	.058	.06
GOLD CREEK	80.	19.2	24.	169	5.	154	8.5	654.	279	146	7.8	.048	.029	.01
BONITA	66.	28.9	18	185	11.	145	8.4	665.	285	170	9.4	.027	.012	.03
TURAH	56.	17.7	11.6	92	37.	87	8.4	456	213	136	5.3	.015	.005	.02
GROVE ST. MISSOULA	41.8	14.4	7.00	142	3.	38.5	8.4	337	164	121	7.4	.015	.004	<.01
HUSON	36.8	14.2	11.8	160	3.	25.4	8.4	337	150	136	3.1	.035	.021	.02

TABLE 4

WATER QUALITY DATA FOR 9 MAINSTREAM STATIONS AND 3 TRIBUTARIES OF THE CLARK FORK RIVER 9/13 & 9/14 1977

	Ca	Mg	Na	K	HCO_3	CO_3	Cl	SO_4	pH	COND	HARD	ALKA	JTU's
DEER LODGE	95	26	26	7.4	200	0.	15.6	205	8.2	703	344	164	.5
GOLD CREEK	103	19.5	24	6.9	182	4.	12.3	242	8.4	744	350	156	.6
BONITA	93	31	19.5	6.3	209	3.	9.7	193	8.3	685	360	176	.3
TURAH	63	17.6	13.4	4.9	156	6.	5.9	117	8.6	481	157	138	.3
BLACKFOOT RIVER ABOVE BONNER	35.5	13.0	4.0	2.1	162	4.	1.7	7.0	8.5	266	142	139	.2
GROVE ST. MISSOULA	49.6	14.1	11.0	3.9	166	0.	5.7	71	8.1	396	182	136	.3
BITTEROOT RIVER AT MISSOULA	31.5	5.7	3.6	3.6	132	0.	3.4	7.4	8.1	225	102	108	.7
HUSON	44.0	10.2	12.5	3.6	162	0.	6.4	41.0	8.2	344	152	133	.2
SUPERIOR	41.0	9.1	11.0	3.3	149	2.	5.4	35.0	8.4	321	140	126	.4
FLATHEAD RIVER AT PERMA	28.0	6.3	2.0	1.1	110	0.	1.7	6.5	8.2	180	96	90	.2
PARADISE	38.5	10.7	10.3	3.2	141	3.	4.7	31.0	8.4	307	140	120	.5
THOMPSON FALLS	31.5	5.7	4.9	2.0	120	0	3.2	12.0	8.2	208	102	99	.6

TABLE 4 (Continued)

WATER QUALITY DATA FOR 9 MAINSTREAM STATIONS AND 3 TRIBUTARIES OF THE CLARK FORK RIVER 9/13 & 9/14 1977

	TP	OPO_4	NO_2NO_3	Hg	Mn	Zn	Cd	Pb	Fe	Cu
DEER LODGE	.068	.045	.20	<.0002	.06	<.01	<.001	<.05	.07	<.01
GOLD CREEK	.040	.022	<.01	<.0002	.09	.02	<.001	<.05	.10	.01
BONITA	.030	.012	.15	<.0002	.03	.02	<.001	<.05	.14	<.01
TURAH	.020	.004	<.01	<.0002	.03	<.01	.001	<.05	.06	<.01
BLACKFOOT RIVER ABOVE BONNER	.009	<.001	<.01	<.0002	<.01	<.01	<.001	<.05	<.05	<.01
GROVE ST. MISSOULA	.140	.120	.69	<.0002	.03	<.01	<.001	<.05	.07	.01
BITTEROOT RIVER AT MISSOULA	.020	.003	.09	<.0002	.02	<.01	<.001	<.05	.07	<.01
HUSON	.034	.013	.01	<.0002	.06	<.01	<.001	<.05	.09	<.01
SUPERIOR	.018	.004	<.01	<.0002	.03	<.01	<.001	<.05	.11	<.01
FLATHEAD RIVER AT PERMA	.009	<.001	<.01	<.0002	<.01	<.01	<.001	<.05	<.05	<.01
PARADISE	.020	.002	<.01	<.0002	.02	<.01	<.001	<.05	.09	<.01
THOMPSON FALLS	.008	.001	<.01	<.0002	<.01	<.01	<.001	<.05	.09	<.01

from above Deer Lodge to above Missoula and three tributary stations were sampled for nutrients and heavy metals once per day during this five day period. The results of these nutrient analyses, a description of sampling stations and a map of the EPA study area is presented in Appendix 8.

B. Diel Dissolved Oxygen and Temperature Sampling

In 1977, fluctuations in dissolved oxygen concentrations were greatest at the Deer Lodge station, with late afternoon high values over 11.0 mg/l and early morning low values near 6.0 mg/l. The most severe dissolved oxygen sags were observed in late July 1977 when the dissolved oxygen dipped below 6.0 mg/l at Bonita. Relatively low river flows coupled with warm weather allowed algal populations to reach densities that depleated dissolved oxygen concentrations (through respriation) to these low nighttime levels. As was mentioned earlier, more extreme fluctuations in dissolved oxygen concentrations were expected in August but did not materialize presumably as a result of unseasonably cool and rainy weather (Appendix 9). Dissolved oxygen, temperature and percent saturation of dissolved oxygen data are presented in Tables 5 through 9. These same data are displayed graphically as percent saturation of dissolved oxygen versus time in Figures 2 through 6. It can be readily seen that dissolved oxygen fluctuations were much less dramatic when the river was sampled during the summer of 1976, which compared to 1977, was a much higher flow year. Data collected on the Clark Fork River by Braico (1973) was also gathered during a relatively low flow (and much warmer) year. Data from this 1973 study is illustrated in Appendices 10-11. For comparative purposes, these appendices have been prepared in the same format as Figures 2-6. This 1973 d.o. and temp. data is tabulated in Appendix 12. Appendix 13 compares river flow data from selected stream gauging stations for the 1973, 1976 and 1977 study periods.

TABLE 5

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT
SATURATION FOR 3 STATIONS ON THE CLARK FORK RIVER 7/20/76

STATION -	DEER LODGE			DRUMMOND			BONITA		
TIME	TEMP	DO	% SAT.	TEMP	DO	% SAT.	TEMP	DO	% SAT.
1 PM	66.5°	9.1	114						
2 PM	69								
3 PM	69.5	8.9	117				67.5°	8.5	105
4 PM	68			67.5°	8.4	105			
5 PM	68	8.0	103				69	8.5	106
6 PM	67			67.5	8.1	101	68.5	8.4	104
7 PM	68	7.6	97				68	7.9	98
8 PM	68						66.5	7.7	93
9 PM	68	7.6	97	65.5	8.3	102	65.5	7.7	92
10 PM	67.5						65	7.6	90
11 PM	67	8.0	101				65	7.5	89
12 MID	66.5			63	7.8	92	64.5	7.4	88
1 AM	65.5	7.6	95				64	7.4	87
2 AM	65.5			61.5	8.1	95	64	7.4	87
3 AM	65	7.3	91				64	7.4	87
4 AM	65			60	8.1	93	64	7.4	87
5 AM	64.5	7.0	88				63.5	7.4	87
6 AM	64						63.5	7.4	87
7 AM	63.5	6.8	84	59.5	8.3	94	63.5	7.4	87
8 AM	63						63.5	7.5	88
9 AM	63	7.0	86				63.5	7.5	88
10 AM	63.5						63	7.7	91
11 AM	64	7.0	86	60	8.5	99	63	7.9	93
12 NOON	64.5						63.5	8.1	95
1 PM	65	8.3	104				65	8.4	100
2 PM				64.5	9.2	112	66	8.6	104
3 PM							67	8.7	106

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TABLE 6

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT SATURATION
FOR 2 STATIONS ON THE CLARK FORK RIVER 7/20/77

	STATION -	DEER LODGE			BONITA		
	TIME	TEMP	DO	% SAT.	TEMP	DO	% SAT.
7/20	3 PM	69°	10.0	129	69°	9.1	114
	4 PM	70	10.0	131	70	8.6	109
	5 PM	71	10.0	132	71	8.4	107
	6 PM	71	9.4	124	71	7.8	100
	7 PM	70.5	8.0	106	70.5	6.9	88
	8 PM	70	7.8	102	70	6.7	85
	9 PM	69.5	7.4	97	69.5	6.6	83
	10 PM	69	6.8	88	69	6.2	77
	11 PM	68	6.4	82	68	6.0	74
	12 MID	67.5	6.0	76	67.5	5.9	73
7/21	1 AM	67	6.0	76	67	5.9	73
	2 AM	66.5	6.0	73	66.5	5.9	71
	3 AM	66	6.0	73	66	5.9	71
	4 AM	65.5	6.0	73	65.5	6.0	73
	5 AM	65	6.2	74	65	6.1	73
	6 AM	64.5	6.4	77	64.5	6.2	74
	7 AM	64	6.6	79	64	6.3	75
	8 AM	63.5	7.0	86	63.5	6.6	78
	9 AM	63	7.7	94	63	7.0	83
	10 AM	62.5	8.5	103	62.5	7.4	87
	11 AM	63.5	9.2	113	63.5	7.6	90
	12 NOON	65.5	9.6	116	65.5	7.9	96
	1 PM	68.5	10.2	132	68.5	8.1	101
	2 PM	70	10.4	136	70	7.5	95
	3 PM	70	10.6	139			

TABLE 7

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT SATURATION
FOR 3 STATIONS ON THE CLARK FORK RIVER 8/3/77

		DEER LODGE			BONITA			HUSON		
	TIME	TEMP	DO	% SAT.	TEMP	DO	% SAT.	TEMP	DO	% SAT.
8/3	12 NOON	66°	10.3	125						
	1 PM	68	10.5	130						
	2 PM	70	11.0	139						
	3 PM	73	11.1	150						
	4 PM	74	11.1	152	74°	9.6	125			
	5 PM	75	10.6	147	73	9.3	121			
	6 PM	73.5	9.7	127	73	8.6	112			
	7 PM	72	9.3	124	72	8.8	114			
	8 PM	70	8.8	115	71	8.2	105	71°	10.4	131
	9 PM	68	8.0	102	70	7.5	95	71	9.8	124
	10 PM	67	7.7	97	69	7.0	87	70.5	9.3	116
	11 PM	65.5	7.0	88	68	6.9	85	70	8.9	111
	12 MID	64.5	6.6	87	67	6.8	83	69.5	8.5	106
8/4	1 AM	64	6.5	79	67	6.8	83	69	8.2	101
	2 AM	63	6.4	78	66	6.8	82	69	8.0	99
	3 AM	63	6.4	78	66	6.8	82	68.5	7.8	95
	4 AM	62.5	6.4	78	66	6.8	82	68	7.5	92
	5 AM	62	6.4	77	66	6.9	83	68	7.3	89
	6 AM	61	6.5	77	65	6.9	83	67.5	7.1	86
	7 AM	60.5	6.7	80	65	7.1	85	67	7.1	86
	8 AM	60.5	6.8	81	64	7.6	91	67	7.2	87
	9 AM	61	7.3	87	65	8.1	97	66.5	7.6	91
	10 AM	61.5	8.3	100	66	8.8	114	66	8.1	97
	11 AM	63.5	9.0	110	67	9.1	111	66.5	8.3	99
	12 NOON	66	9.8	123	66	8.9	108	66.5	8.5	102
	1 PM				65	8.7	104	67	8.5	103
	2 PM				66	9.0	109	67.5	8.7	105
	3 PM				67	9.3	114	67	9.0	109
	4 PM				70	9.9	125			

TABLE 3

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT SATURATION
FOR 2 STATIONS ON THE CLARK FORK RIVER 8/17/77

	STATION -	DEER LODGE			BONITA		
	TIME	TEMP	DO	% SAT.	TEMP	DO	% SAT.
8/17	10 AM	59°	9.7	106			
	11 AM	62	10.0	121			
	12 NOON	64	10.4	129	68°	9.6	129
	1 PM	66	10.6	133	70	9.8	124
	2 PM	67	10.9	138	71	9.7	124
	3 PM	69	11.2	145	73	9.5	121
	4 PM	71	11.1	147	74	9.4	124
	5 PM	72	10.9	146	74	8.9	118
	6 PM	73	10.6	143	74	8.8	116
	7 PM	74	10.1	138	74	8.2	108
	8 PM	74	9.3	127	73	7.6	99
	9 PM	73	8.2	111	72	6.8	88
	10 PM	72	7.3	98	70	6.5	82
	11 PM	71	6.7	89	69	6.4	80
	12 MID	70	6.4	84	68	6.3	78
8/18	1 AM	69	6.3	81	68	6.3	78
	2 AM	67	6.3	80	67	6.4	78
	3 AM	66	6.2	78	66	6.4	77
	4 AM	65	6.3	78	65.5	6.4	77
	5 AM	64.5	6.4	79	65	6.6	79
	6 AM	64	6.5	80	64	6.7	80
	7 AM	63.5	6.6	81	64	7.0	84
	8 AM	63	6.7	81	63	7.6	89
	9 AM	63	7.1	86	64	8.7	104
	10 AM	63.5	8.0	98	66	9.2	111
	11 AM	65	8.9	110	68	9.6	119
	12 NOON	66	9.5	119	71	10.1	129
	1 PM	68	9.9	127			
	2 PM	69	10.3	133			
	3 PM	72	10.6	142			

TABLE 9

TIME, TEMPERATURE, DISSOLVED OXYGEN, AND PERCENT SATURATION FOR THE CLARK FORK RIVER AT BONITA 9/13/77

	TIME	TEMP	DO	% SAT.
	11 AM	57°	10.0	109
	12 NOON	58	10.4	115
	1 PM	59	10.5	117
	2 PM	60	10.6	120
	3 PM	61	10.5	121
	4 PM	62	10.0	116
	5 PM	62	9.6	111
	6 PM	63	9.2	108
	7 PM	64	8.4	97
	8 PM	63	7.6	89
	9 PM	62	7.3	85
	10 PM	61	7.2	83
	11 PM	60	7.1	81
	12 MID	60	7.1	81
9/14	1 AM	59	7.1	79
	2 AM	59	7.1	79
	3 AM	58	7.1	78
	4 AM	58	7.1	78
	5 AM	57	7.2	79
	6 AM	57	7.4	81
	7 AM	56	7.5	81
	8 AM	56	8.0	87
	9 AM	55	8.8	94
	10 AM	56	9.8	106
	11 AM	57	10.3	113

FIGURE 2

DIEL DISSOLVED OXYGEN AS PERCENT SATURATION VERSUS TIME

Clark Fork 7-20-76

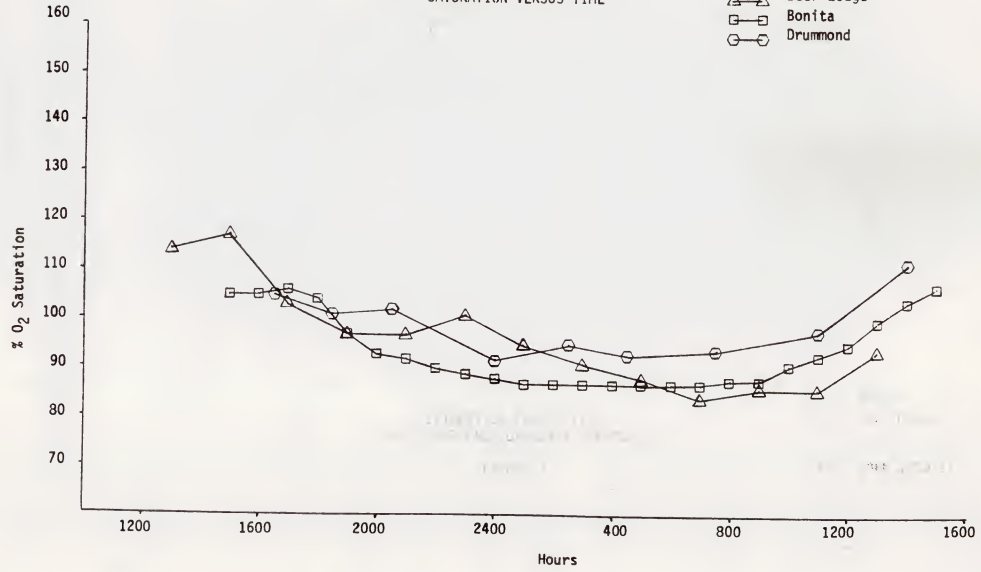


FIGURE 3

DIEL DISSOLVED OXYGEN AS PERCENT SATURATION VERSUS TIME

Clark Fork 7-20-77

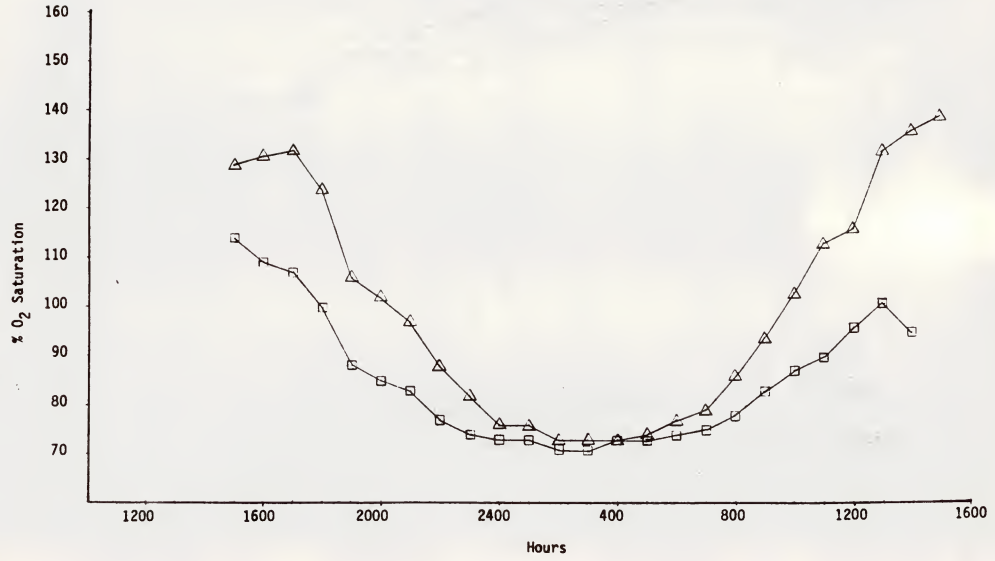


FIGURE 4

DIEL DISSOLVED OXYGEN AS PERCENT SATURATION VERSUS TIME

Clark Fork 8/3/77

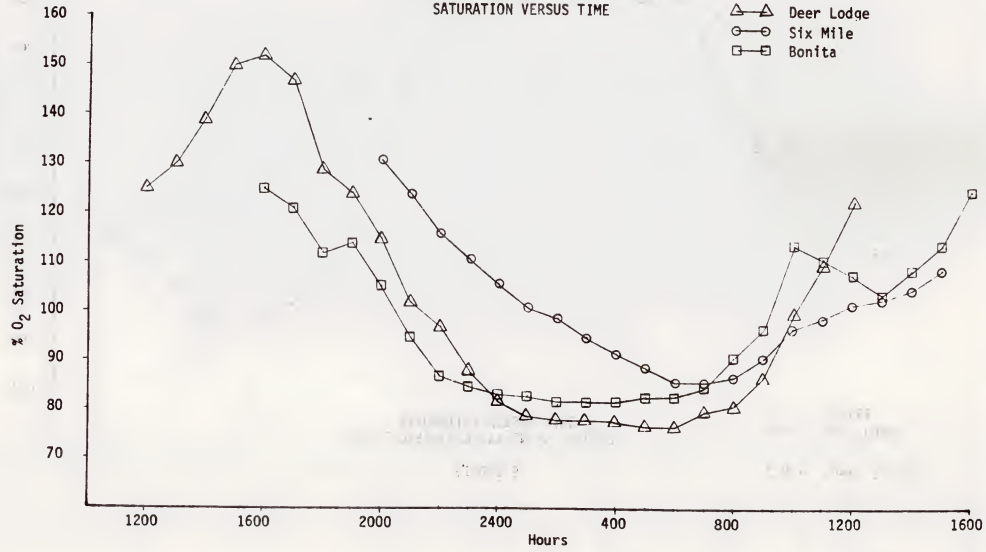


FIGURE 5

Clark Fork 8/17/77

DIEL DISSOLVED OXYGEN AS PERCENT SATURATION VERSUS TIME

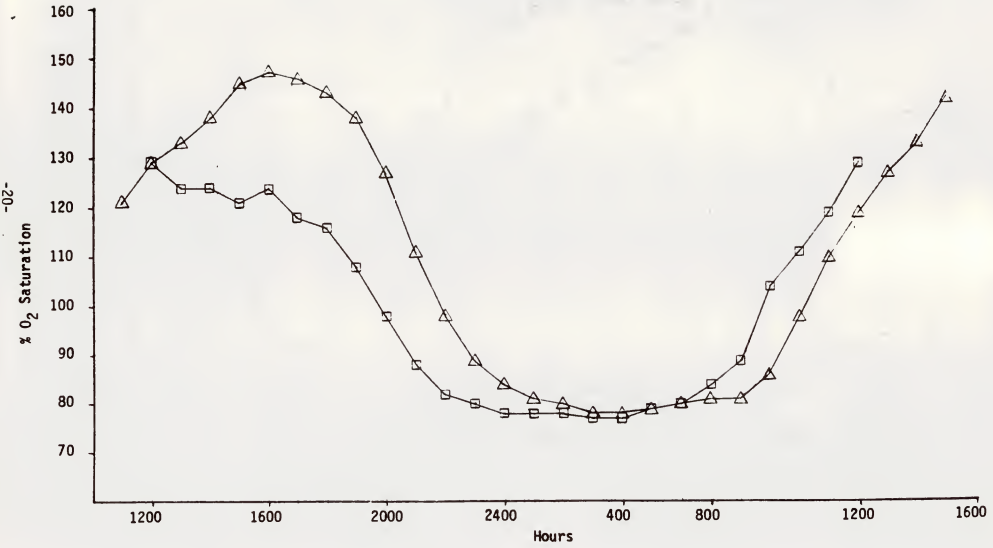
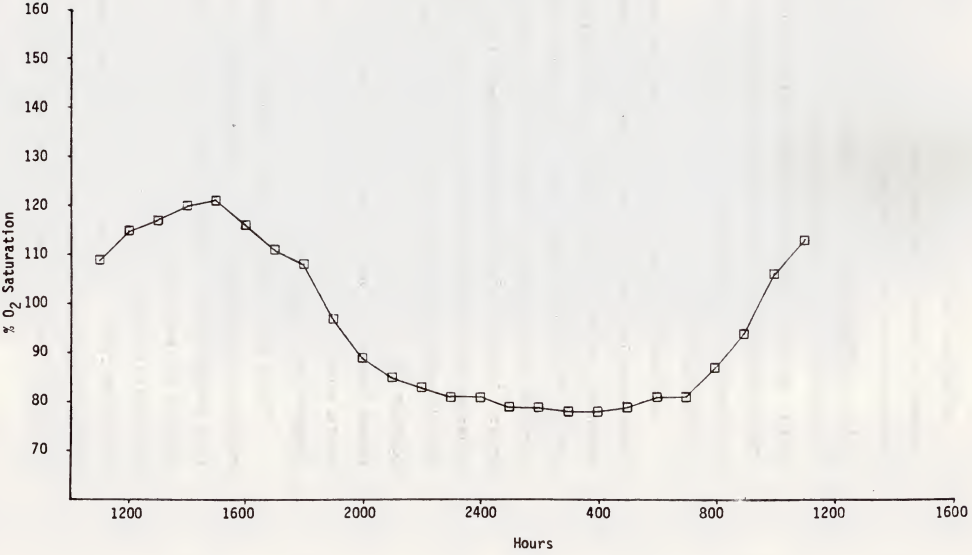


FIGURE 6

DIEL DISSOLVED OXYGEN AS PERCENT SATURATION VERSUS TIME

Clark Fork 9/13/77

Bonita



It should be noted that violations of the state water quality standard for dissolved oxygen were recorded both at Deer Lodge and Bonita during August of 1973 and during July and August of 1977. In fact, violations occurred at all stations in 1973. The Clark Fork is classified as a $C\text{-}D_1$ stream at Deer Lodge and as a $B\text{-}D_1$ stream at Bonita. For both of these classifications, water quality is to be "Maintained suitable for growth and propagation of salmonid fishes" and Dissolved Oxygen concentration is not to be reduced below 7.0 milligrams per liter."

It is important to maintain sufficient dissolved oxygen concentrations in the Clark Fork River, not only because of the requirements within the State Water Quality Standards, but also because of the needs of fish and other aquatic life. In fact, these standards are based upon the respiratory requirements of fish and aquatic invertebrates. To maintain a highly productive salmonid fishery, the dissolved oxygen must be consistently maintained above 6.0 mg/L, and preferably above 7.0 mg/L (Herman, Warren and Doudoroff 1962; Shumway, Warren and Doudoroff 1964; EPA 1973). Wide diel fluctuations of dissolved oxygen between tolerable but very low and high levels are nearly as harmful to aquatic animals as is continuous exposure to low dissolved oxygen levels (Doudoroff and Shumway 1967).

Elevated stream temperatures when combined with suboptimal dissolved oxygen levels have an additive (or synergetic) impact upon salmonid populations (Garside 1966). The upper maximum average weekly temperature for growth of both rainbow and brook trout is reported to be $19^{o}C$ ($66^{o}F$), while $24^{o}C$ ($75^{o}F$) is the short term maximum temperature for survival of these species (ERL 1976). These same critical temperature extremes are even lower for brown trout, with the upper limit for growth being $17^{o}C$ ($62.5^{o}F$) and $23.5^{o}C$ ($74.5^{o}F$) being the upper incipient lethal temperature (EPA 1973).

When dissolved oxygen levels are below those needed for optimum growth of salmonids, which as mentioned above is between 6.0 and 7.0 mg/L, these critical temperature limits are likely to be even lower.

The Region 2 Office of the Montana Department of Fish and Game in Missoula maintained a constant recording thermograph at Bonita during the summer of 1977. Maximum stream temperatures above 74.5°F were recorded on seven separate days from July 22 through August 19. Also, average weekly temperatures exceeded 62.5°F from early July through late August (Appendix 14). The Missoula office has indicated that this thermograph will continue to be operated, since the Clark Fork River immediately above the confluence of Rock Creek is an extremely critical river segment, where summer temperature and/or dissolved oxygen levels could very easily become toxic to salmonid populations. Thermographs will also be maintained at Gold Creek and Bearmouth, which is midway between Bonita and Gold Creek.

C. Periphyton Sampling

Biomass accrual determinations (as dry and ash dry weights) have not yet been completed. However, periphyton biomass as mg/M^2/day chlorophyll-a have been calculated for stations where slides were recovered. This data is arranged in Table 10 and is rather spotty as a result of vandalism. However, some trends can be pointed out. Large biomass accumulations seem to occur at stations that had high concentrations of nitrate and phosphate. The Gold Creek station had very low accumulations of algal biomass. This station, however, was dominated by Cladophora, a large perennial algae. During the summer of 1977, conspicuously low nutrient concentrations and biomass accumulations were also found within areas dominated by Cladophora in the Yellowstone River (Knudson, 1977).

TABLE 10

PERIPHYTON BIOMASS AS CHLOROPHYLL-A ($Mg/M^2/Day$) FROM MICROSCOPE SLIDES SUSPENDED IN ARTIFICIAL SUBSTRATES AT SIX STATIONS ON THE CLARK FORK RIVER. INCUBATION PERIODS VARIED FROM 7 TO 14 DAYS.

	8/3/77		8/11/77		8/13/77		9/14/77	
STATION	# of Slides	$Mg/M^2/Day$	# of Slides	$Mg/M^2/Day$	# of Slides	$Mg/M^2/Day$	# of Slides	$Mg/M^2/Day$
DEER LODGE			3	1.36	2	.97		
GOLD CREEK	2	.07	3	.22	2	.05		
BONITA	1	.71			3	.49	3	1.03
TURAH	2	.81					3	.48
GROVE ST.							3	1.56
HUSON	3	2.22						

D. Situation Statement

Additional studies to further explore the nutrient/algae/dissolved oxygen problem are planned for the upper Clark Fork River. These studies are intended to support the need for a reservation of river flow that will adequately protect the fish and wildlife resources of the river. Inherent in any such minimum flow request is the need to understand the impacts of increased nutrient loading, temperature, and dewatering upon algal productivity and subsequently, the dissolved oxygen regime of this segment of the river. Ultimately, of course, these impacts must be related to the salmonid fishery.

Although mining and milling wastes must always be considered as potential threats to the water quality of the Upper Clark Fork River, the pollution control efforts at the Anaconda Company's Butte and Anaconda operations have significantly reduced the heavy metal contamination that had historically depleted the sport fishery in the river above Missoula. The Company's lower settling ponds have also provided nutrient removal (tertiary treatment) for the total of the domestic wastes from these two cities. A continuation of this latter treatment, or a similar type of treatment by the cities themselves, may be necessary to insure the continual recovery of the river. Increased dewatering by agriculture and (potential) fertilizer and petroleum-related developments also present severe threats, as do the nutrient-enriched and/or heated discharges generated by these activities. It would be a lamentable situation if the recently reestablished, and highly successful, salmonid fishery were to be lost again to more insidious, eutrophication-related water quality and quantity problems.

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Appendix 1
USGS Data
Deer Lodge and Galen

DEER LODGE

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	NITRATE (N) (MG/L)	NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	ORTHO PHOSPHATE (PO4) (MG/L)	DISSOLVED ORTHO PHOSPHATE (PO4) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIOCHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS (CA,MG) (MG/L)	ALKALINITY AS CACO3 (MG/L)
OCT.														
17...	0845	259	3.5	.60	.10	.03	.12	--	.06	.11	7.0	1.0	598	126
NOV.														
14...	0710	296	3.0	.60	.03	.08	.25	--	.15	.30	6.0	2.3	631	126
DEC.														
30...	0930	238	.0	.80	.00	.10	.35	--	.10	.12	2.0	1.7	693	146
JAN.														
15...	1700	358	.0	.70	.06	--	1.4	--	.03	.04	2.0	1.9	749	116
FEB.														
12...	1115	282	2.5	.60	.04	.09	.28	--	.10	.17	2.0	1.0	696	116
MAR.														
19...	0715	282	.5	.50	.00	.15	.30	--	.04	.07	1.0	7.2	659	113
APR.														
16...	0815	364	2.0	.50	.00	.24	.89	--	.04	.11	2.0	2.1	691	101
MAY														
15...	1510	411	12.5	.40	.00	.00	.28	--	.07	.12	3.0	1.9	572	92
JUNE														
11...	0830	816	9.5	.10	.00	.04	.25	--	.03	.13	1.0	0.8	332	61
JULY														
13...	0815	298	16.5	.35	.00	.01	.42	.15	.05	.05	2.0	0.9	616	105
AUG.														
06...	1200	214	17.0	.30	.00	.04	.25	.06	.07	.08	4.0	1.4	722	120
SEPT.														
11...	0715	250	11.0	.48	--	.01	--	.14	.06	.06	--	1.3	--	108

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	NITRATE (N) (MG/L)	NITRITE (N) (MG/L)	AMMONIA NITRATE (N) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	DISSOLVED ORTHO PHOSPHORUS (P) (MG/L)	DISSOLVED ORTHO PHOSPHATE (PO4) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIOCHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS (CA,MG) (MG/L)	ALKALINITY AS CACO3 (MG/L)
OCT.			4.5										690	126
08...	0900	229		.5	.020	--	.05	.30	.070	.22	.10	9.0	--	121
NOV.			3.0										--	
05...	0735	290		.6	--	--	.10	--	.030	.08	.050	28	.8	120
DEC.			1.0										--	
02...	1630	340		.7	--	--	.06	--	.050	.01	.12	5.0	1.7	
JAN.													740	130
06...	1530	253	.0	--	.060	.20	.12	--	--	.00	--	3.0	2.3	
FEB.													--	92
03...	1410	410	1.5	--	--	.50	.31	--	--	.01	.13	130	4.3	
MAR.													--	105
05...	0900	305	.0	--	--	.20	.58	--	--	.10	.070	11	1.4	
APR.													730	106
08...	1630	325	8.5	.4	.040	.40	.06	.20	.020	.15	.090	2.0	1.6	
MAY													--	77
06...	0110	575	10.5	--	--	.40	.21	--	--	.15	.18	7.0	2.0	
JUNE													--	
04...	1300	582	12.5	--	--	.26	.14	--	--	.12	.10	5.0	1.9	75

GALEN

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	DISSOLVED NITRATE (N) (MG/L)	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	DISSOLVED AMMONIA NITROGEN (N) (MG/L)	ORGANIC NITROGEN (N) (MG/L)	TOTAL NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	DISSOLVED ORTHO PHOSPHORUS (P) (MG/L)	DISSOLVED ORTHO PHOSPHORUS (P) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIOCHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS (CA,MG) (MG/L)	ALKALINITY AS CACO3 (MG/L)
OCT.																
13...	1300	129	6.4	.38	.40	.19	.19	.78	.38	.12	.000	.16	.0	2.4	790	67
JAN.																
04...	1400	109	.0	.54	.55	.68	.92	2.2	1.6	.010	.010	.20	2.0	5.2	1200	80
APR.																
18...	1230	221	5.0	.37	.39	.40	.08	.81	.48	.10	.020	.10	.0	2.2	1100	61
JULY																
19...	1500	94	13.5	--	.19	--	--	.41	.22	.030	.010	.090	--	1.3	1200	41

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	DISSOLVED NITRITE PLUS NITRATE (N) (MG/L)	TOTAL NITRITE PLUS NITRATE (N) (MG/L)	TOTAL NITRITE (N) (MG/L)	TOTAL NITROGEN (N) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)	DISSOLVED ORTHO PHOSPHORUS (P) (MG/L)	TOTAL ORTHO PHOSPHORUS (P) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	BIOCHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS (CA,MG) (MG/L)	ALKALINITY AS CACO3 (MG/L)
OCT.														
17...	1045	99	6.0	.56	--	.98	.62	.01	.10	.03	1.6	570	58	
NOV.														
14...	1015	131	.5	.45	--	1.8	1.3	.01	.00	.06	5.8	656	56	
MAY														
19...	1500	94	7.0	.26	.29	.04	.65	.01	.01	.04	3.5	459	74	
JULY														
23...	1415	91	20.5	.04	.06	.09	.63	.01	.01	.02	2.0	448	51	
SEPT.														
10...	0700	212	13.5	.19	.19	.49	.35	.01	.01	.08	2.8	760	55	

Appendix 2
USGS Data
Garrison & Drummond

GARRISON

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1970

DATE	TIME	DIS-CHARGE (CFS)	TEMP (FAHRNH) (DEG C)	NITRATE (NO3) (MG/L)	NITRITE (NO2) (MG/L)	AMMONIA NITRO-GEN (NH3) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.														129
17...	1110	197	4.5	.40	.00	.00	.24	--	.05	.06	6.3	.7	561	
NOV.														136
14...	1130	456	3.5	.40	.00	.01	.21	--	.16	.16	9.0	1.7	512	
DEC.														123
5...	1545	108	.0	.70	.00	.10	.12	--	.14	.16	1.0	2.0	626	
JAN.														126
12...	1250	161	.0	.60	.00	1.1	1.9	--	.07	.21	2.0	1.5	641	
FEB.														135
17...	1500	377	2.5	.60	.05	.07	.19	--	.08	.12	2.0	1.3	583	
MAR.														123
18...	1215	935	2.5	.53	.00	.08	.37	--	.05	.09	3.0	2.2	535	
APR.														115
14...	1230	496	4.0	.49	.01	.18	.01	--	.08	.15	1.0	1.7	503	
MAY														100
14...	1745	935	11.0	.28	.00	.01	.21	--	.08	.09	3.0	1.4	381	
JUNE														85
11...	1130	1630	9.5	.51	.07	.01	.66	--	.01	.10	1.0	1.6	200	
JULY														123
13...	1200	510	19.5	.13	.01	.01	.29	.28	.09	.07	4.0	1.1	326	
AUG.														115
04...	1600	176	21.5	.07	.00	.05	.73	.09	.06	.10	2.0	1.9	513	
SEPT.														123
11...	1030	278	9.5	.34	--	.02	--	.13	.12	.21	.9	2.0	--	

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DIS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE (NO3) (MG/L)	NITRITE (NO2) (MG/L)	AMMONIA NITRO-GEN (NH3) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.														106
08...	1145	918	4.5	.4	.010	--	.03	.21	.080	.15	.080	17	--	540
NOV.														131
05...	1000	329	5.0	.6	--	--	.09	--	.050	.12	.060	12	.8	--
DEC.														129
03...	0800	381	.0	.7	--	--	.18	--	.040	.01	.070	5.0	2.7	--
JAN.														
06...	1030	370		-	.050	.10	.70	.01	--	.00	--	.0	2.7	720
FEB.			.0											188
03...	1115	660		-	-	.20	.12	--	--	.10	.16	11	4.2	--
MAR.			.5											97
05...	1200	419		-	--	.10	.43	--	--	.10	.070	3.0	1.1	--
APR.			.0											114
06...	1000	480		.3	--	-	--	--	--	.04	--	3.0	1.9	510
MAY			5.0											106
06...	0915	1130		--	--	.30	.00	--	-	.12	.12	5.0	2.0	--
JUNE			9.0											77
02...	1230	1460		--	--	.14	.11	--	--	.15	.10	4.0	1.2	--
			10.0											81

DRUMMOND

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFS)	TEMPER-ATURE (DEG C)	DIS-SOLVED NITRATE (NO3) (MG/L)	DIS-SOLVED NITRITE PLUS NITRATE (NO3) (MG/L)	DIS-SOLVED AMMONIA NITRO-GEN (NH3) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	TOTAL NITRO-GEN (N) (MG/L)	TOTAL RECO-VERABLE NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.															162
13...	1810	556	8.5	.09	.00	.07	.14	.21	.21	.070	.010	.090	.6	2.0	303
JAN.															152
04...	1510	455	.0	.20	.20	.17	.30	.67	.47	.040	.010	.080	4.0	1.7	450
APR.															130
12...	0930	989	3.5	.11	.11	.03	.33	.47	.16	.010	.000	.090	3.6	2.3	290
JULY															148
21...	1700	580	12.0	--	.00	--	--	--	.34	.14	.10	.17	--	1.8	289

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DIS-CHARGE (CFS)	TEMPER-ATURE (DEG C)	DIS-SOLVED NITRITE PLUS NITRATE (NO3) (MG/L)	TOTAL NITRITE PLUS NITRATE (NO3) (MG/L)	TOTAL NITRO-GEN (N) (MG/L)	TOTAL KJEL-DAHL NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.													
14...	1615	414	7.5	.04	--	.29	.25	.02	.10	.04	1.6	329	145
NOV.													
16...	1439	440	.5	.43	--	1.1	.65	.05	.10	.12	2.1	308	135
DEC.													
19...	1615	545	4.5	.09	.13	.52	.39	.01	.02	.06	3.5	240	160
JAN.													
24...	0915	395	12.5	.01	.02	.41	.36	.00	.05	.06	1.6	320	208
APR.													

Appendix 3
USGS Data
Alberton

ALBERTON

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DIS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE (N) (MG/L)	NITRITE (N) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.														
17...	1610	3200	5.0	.10	.06	.00	.12	--	.02	.17	7.0	1.9	173	126
NOV.														
12...	1430	2900	7.0	.40	.00	.01	.80	--	.17	.52	8.0	1.6	167	123
DEC.														
16...	1440	2450	1.5	.20	.08	.01	.09	--	.05	.16	2.0	1.1	198	121
JAN.														
13...	0930	2800	.0	.38	.00	.04	.43	--	.07	.12	3.0	1.7	180	110
FEB.														
11...	0945	2400	2.0	.20	.00	.12	.29	--	.05	.08	2.0	1.2	187	112
MAR.														
17...	1730	2850	5.0	.30	.00	.04	.26	--	.05	.07	3.0	2.5	180	107
APR.														
15...	1145	1500	6.0	.12	.00	.00	.18	--	.05	.06	2.0	1.3	162	100
MAY														
13...	1615	11400	8.0	.07	.00	.00	.20	--	.04	.08	5.0	2.3	90	71
JUNE														
09...	1750	36100	12.5	.06	.00	.46	1.3	--	.01	.16	2.0	1.3	60	46
JULY														
11...	1115	7900	17.5	.04	.00	.01	.19	.02	.01	.06	19	1.0	111	79
AUG.														
04...	1945	3953	21.0	.01	.00	.04	.10	.01	.02	.11	49	1.7	146	102
SEPT.														
09...	1200	2500	13.0	.03	--	.01	--	.04	.02	.03	11	1.5	--	120

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DIS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE (N) (MG/L)	NITRITE PLUS NITRATE (N) (MG/L)	NITRITE (N) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.															
06...	1230	2840	10.5	.00	.010	--	.02	.22	.020	.04	.040	2.0	--	160	116
NOV.															
03...	1200	2900	1.5	.5	--	--	.01	--	.020	.03	.020	54	1.6	--	116
DEC.															
01...	1610	3230	3.0	.1	--	--	.01	--	.030	.04	.080	.0	1.5	--	92
JAN.															
07...	0930	1510	1.5	--	.020	.10	.06	.02	--	.01	--	20	.8	180	121
FEB.															
02...	1200	12100	2.5	--	--	.50	.00	--	--	.23	.20	4.0	3.0	--	49
MAR.															
03...	1300	3590	1.5	--	--	.10	.05	--	--	.10	.010	.0	.8	--	97
APR.															
07...	1245	4170	8.5	.1	.030	.10	.27	.20	.020	.12	.20	2.0	1.2	150	80
MAY															
04...	1100	26500	10.0	--	--	.10	.08	--	--	.12	.20	4.0	2.4	--	63
JUNE															
01...	0930	29200	10.5	--	--	.01	.01	--	--	.12	.070	.0	.9	--	51

Appendix 4
USGS Data
Above Missoula

ABOVE MISSOULA

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DIS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE (N) (MG/L)	NITRITE (N) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.														
16...	1930	1810	3.5	.16	.00	.00	.00	--	.02	.07	6.0	.8	260	144
NOV.														
13...	0810	1690	5.0	.00	.00	.01	.14	--	.18	.24	7.0	.9	248	136
DEC.														
18...	1730	1450	.5	.20	.00	.00	.10	--	.08	.12	2.0	.8	280	133
JAN.														
15...	1145	1600	.0	.30	.00	.01	.47	--	.00	.04	4.0	1.1	277	128
FEB.														
11...	1230	1180	1.0	.20	.00	.07	.16	--	.02	.03	2.0	1.4	290	128
MAR.														
18...	0810	1580	3.0	.11	.00	.01	.36	--	.08	.08	4.0	2.4	247	128
APR.														
15...	1630	2010	5.0	.14	.00	.00	.20	--	.05	.16	8.0	1.2	236	120
MAY														
13...	2000	7190	8.0	.04	.00	.06	.47	--	.05	.10	5.0	2.8	121	80
JUNE														
10...	0840	15300	10.5	.09	.00	.00	.26	--	.05	.21	1.0	1.6	90	69
JULY														
12...	0915	3810	17.0	.01	.00	.01	.16	.12	.05	.03	5.0	.9	163	116
AUG.														
05...	1445	2240	18.0	.00	.00	.02	.08	.01	.02	.14	3.0	.5	187	115
SEPT.														
10...	0930	1400	12.5	.02	--	.00	--	.06	.03	.11	1.0	1.2	--	130

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DIS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE (N) (MG/L)	NITRITE (N) (MG/L)	NITRITE PLUS NITRATE (N) (MG/L)	AMMONIA NITRO-GEN (N) (MG/L)	ORGANIC NITRO-GEN (N) (MG/L)	DIS-SOLVED PHOS-PHORUS (P) (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	TOTAL ORGANIC CARBON (C) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.															
07...	0830	1890	7.0	.00	.010	--	.03	.22	.040	.09	.060	25	--	220	134
NOV.															
04...	0730	1610	2.0	.1	--	--	.02	--	.010	.01	.020	.0	.8	--	111
DEC.															
02...	0900	1440	2.0	.2	--	--	.01	--	.010	.01	.020	4.0	.8	--	125
JAN.															
06...	1000	1000	.5	--	.020	.40	.00	.02	--	.00	--	.0	1.1	270	138
FEB.															
02...	1445	5300	1.5	--	--	.40	.08	--	--	.20	.20	4.0	3.2	--	87
MAR.															
03...	1730	2000	.5	--	--	.10	.05	--	--	.10	.050	2.0	.9	--	110
APR.															
07...	1730	2630	8.0	.00	.010	.00	.76	.20	.020	.06	.090	1.0	1.0	230	109
MAY															
04...	1720	10800	10.5	--	--	.10	.00	--	--	.09	.060	1.0	1.7	--	72
JUNE															
02...	1700	13900	11.0	--	--	.01	.08	--	--	.12	.090	48	.8	--	75

Appendix 5
USGS Data
Thompson Falls

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DIS-CHARGE (CFST	TEMP-ERATURE (DEG CE	NITRATE (NI (MG/L)	NITRITE (NI (MG/L)	AMMONIA NITRO-GEN (NI (MG/L)	ORGANIC NITRO-GEN (NI (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PHAT (MG/L)	DIS-SOLVED PHOS-PHORUS (PT (MG/L)	TOTAL PHOS-PHORUS (PT (MG/L)	TOTAL ORGANIC CARBON (CI (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L	HARD-NESS (CA+MGI (MG/L)	ALKA-LINITY AS (CACOI (MG/L)
OCT.														
15...	1600	15400	1.0	.00	.00	.31	.18	--	.01	.12	5.0	1.0	107	99
NOV.														
12...	0715	8600	6.0	.00	.00	.01	.11	--	.08	.28	5.0	.8	148	107
DEC.														
10...	0915	15800	2.0	.00	.00	.01	--	--	.00	.03	2.0	.9	111	97
JAN.														
14...	1040	17100	.0	.10	.00	.01	.18	--	.03	.17	2.0	1.0	108	93
FEB.														
16...	1300	8400	3.0	.00	.00	.09	.12	--	.02	.02	2.0	.7	120	104
MAR.														
11...	1100	10300	5.0	.03	.00	.04	.12	--	.07	.12	1.0	1.2	115	100
APR.														
15...	0640	15800	6.5	.04	.00	.00	.14	--	.02	.04	2.0	.8	105	90
MAY														
13...	0830	37900	7.5	.10	.00	.00	.16	--	.06	.09	3.0	1.3	80	75
JUNE														
09...	1039	98000	14.5	.01	.00	.02	.37	--	.00	.10	.0	1.3	68	62
JULY														
22...	1200	14500	22.0	.01	.00	.02	.08	.06	.00	.04	5.0	1.2	96	94
AUG.														
19...	1300	7800	19.5	.00	.00	.01	.06	.01	.01	.02	10	1.0	104	107
SEPT.														
15...	0930	15000	11.5	.00	--	.01	--	.08	.04	.04	7.0	.8	--	100

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DATE	TIME	DIS-CHARGE (CFST	TEMP-ERATURE (DEG CE	NITRATE (NI (MG/L)	NITRITE (NI (MG/L)	NITRITE PLUS NITRATE (NI (MG/L)	AMMONIA NITRO-GEN (NI (MG/L)	ORGANIC NITRO-GEN (NI (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PHAT (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (PT (MG/L)	TOTAL PHOS-PHORUS (PT (MG/L)	TOTAL ORGANIC CARBON (CI (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L	HARD-NESS (CA+MGI (MG/L)	ALKA-LINITY AS (CACUS (MG/L)
OCT.															
13...	0900	17600	9.0	.60	.000	--	.00	.35	.020	.02	.040	1.0	.9	110	99
NOV.															
12...	1030	9030	5.0	.80	--	--	.01	--	--	.01	.610	4.0	.9	--	105
DEC.															
09...	1000	17600	2.0	.00	--	--	.05	--	--	.02	.040	13	1.2	--	103
JAN.															
20...	0900	17500	.0	--	.020	.00	.00	.09	.010	.02	--	1.0	2.2	91	80
FEB.															
16...	0900	14000	4.0	--	--	.20	.14	--	.020	.00	.030	1.0	1.1	--	81
MAR.															
16...	0900	14600	4.0	--	--	.10	.31	--	.000	.01	.010	5.0	.5	--	91
APR.															
13...	0900	20500	4.5	.1	.000	.10	.34	.40	.020	.01	.040	8.0	2.0	94	82
MAY															
18...	0730	81000	8.0	--	--	.00	.02	--	--	.12	.10	2.0	.9	--	66
JUNE															
08...	0800	83100	11.0	--	--	.01	.05	--	--	.06	.050	4.0	1.1	--	68
JULY															
27...	0900	21400	21.0	--	--	--	--	--	--	--	--	--	--	90	80
AUG.															
17...	0830	10400	21.5	.6	.000	.68	.11	--	.030	.00	.050	8.0	1.2	--	84
SEP.															
14...	0900	11400	14.5	--	--	--	--	--	--	--	--	--	1.1	--	93

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFST	TEMPER-ATURE (DEG CE	DIS-SOLVED NITRATE (NI (MG/L)	DIS-SOLVED NITRITE PLUS NITRATE (NI (MG/L)	DIS-SOLVED AMMONIA NITRO-GEN (NI (MG/L)	ORGANIC NITRO-GEN (NI (MG/L)	TOTAL NITRO-GEN (NI (MG/L)	TOTAL KJEL-DAHL NITRO-GEN (NI (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (PT (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (PT (MG/L)	TOTAL PHOS-PHORUS (PT (MG/L)	TOTAL ORGANIC CARBON (CI (MG/L)	HARD-NESS (CA+MGI (MG/L)	ALKA-LINITY AS (CACO3 (MG/L)
OCT.															
13...	0830	10700	11.5	.00	.01	.01	.16	.18	.17	.070	.010	.080	2.0	110	95
JAN.															
04...	0810	17500	.0	.05	.05	.06	.36	.47	.42	.010	.000	.020	2.0	100	90
APR.															
17...	0810	31500	5.5	.00	.00	.10	.07	.17	.17	.010	.000	.040	.0	95	80
JULY															
11...	0930	34000	18.0	--	.01	--	--	.09	.08	.020	.000	.020	--	77	75

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DIS-CHARGE (CFS)	TEMPER-ATURE (DEG CE	DIS-SOLVED NITRITE PLUS NITRATE (NI (MG/L)	TOTAL NITRITE PLUS NITRATE (NI (MG/L)	TOTAL NITRO-GEN (NI (MG/L)	TOTAL NITRO-GEN (NI (MG/L)	TOTAL KJEL-DAHL NITRO-GEN (NI (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL ORTHO PHOS-PHORUS (P) (MG/L)	TOTAL PHOS-PHORUS (P) (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L	HARD-NESS (CA+MG) (MG/L)	ALKA-LINITY AS (CACO3 (MG/L)
OCT.														
20...	1035	13000	8.0	.01	--	.10	.09	.00	.08	.04	1.0	114	85	
JAN.														
16...	1040	14000	.5	.06	--	.25	.19	.00	.08	.05	1.0	98	91	
MAR.														
14...	1004	11500	4.0	.06	.08	.14	.14	.00	.01	.03	1.4	94	106	
MAY														
15...	1130	17000	14.0	--	--	--	--	--	--	--	1.0	76	81	
SEP.														
26...	1230	21200	14.5	--	--	--	--	--	--	--	.9	84	80	
NOV.														
12...	1004	14400	20.0	.00	.00	.20	.20	.00	.00	.01	1.0	44	98	
JAN.														
09...	1030	6180	20.5	.00	.00	.08	.08	.01	.00	.03	.7	47	91	

Appendix 6
USGS Data
Bitterroot River

BITTERROOT RIVER AT MACLAY BRIDGE

CHEMICAL ANALYSES, JULY TO SEPTEMBER 1970

DATE	TIME	DIS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE INI (MG/L)	NITRITE INI (MG/L)	AMMONIA NITRO-GEN INI (MG/L)	ORGANIC NITRO-GEN INI (MG/L)	DIS-SOLVED ORTHO PHOS-PHATE (PO4) (MG/L)	DIS-SOLVED PHOS-PHORUS IPI (MG/L)	TOTAL PHOS-PHORUS IPI (MG/L)	TOTAL ORGANIC CARBON ICI (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
JULY														
11...	1500	1430	18.0	.04	.00	.01	.20	.25	.09	.09	1.0	.8	45	44
AUG.														
05...	1100	1290	19.0	.07	.00	.03	.15	.00	.01	.06	3.0	.2	75	78
SEPT.														
09...	1530	950	15.0	.05	.00	.00	.31	.03	.03	.02	5.0	2.0	--	100

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFS)	TEMPER-ATURE (DEG C)	DIS-SOLVED NITRATE INI (MG/L)	DIS-SOLVED NITRITE PLUS NITRATE INI (MG/L)	DIS-SOLVED AMMONIA NITRO-GEN INI (MG/L)	ORGANIC NITRO-GEN INI (MG/L)	TOTAL NITRO-GEN INI (MG/L)	TOTAL KJEL-DAHL NITRO-GEN INI (MG/L)	DIS-SOL-VED PHOS-PHORUS (ORTHO) IPI (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS IPI (MG/L)	TOTAL PHOS-PHORUS IPI (MG/L)	TOTAL ORGANIC CARBON ICI (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.																
14...	0945	970	8.0	.10	.08	.02	.12	.22	.14	.050	.040	.090	1.0	2.3	90	94
NOV.																
18...	0930	880	4.5	--	--	--	--	--	--	--	--	--	--	2.1	--	84
DEC.																
09...	1200	820	1.0	--	--	--	--	--	--	--	--	--	--	1.3	--	84
JAN.																
04...	0900	600	.0	.17	.17	.06	.26	.49	.32	.020	.010	.040	2.0	1.9	77	85
FEB.																
15...	1700	980	2.5	--	--	--	--	--	--	--	--	--	--	1.5	--	74
MAR.																
21...	0830	3950	5.0	--	--	--	--	--	--	--	--	--	--	1.1	--	62
APR.																
17...	1700	2660	8.5	.01	.01	.03	.18	.22	.21	.000	.000	.050	1.0	1.6	53	51
MAY																
16...	1530	17000	10.0	--	.08	--	--	--	--	.020	.000	--	--	2.1	21	20
JUNE																
13...	1530	21900	11.0	--	--	--	--	--	--	--	--	--	--	1.2	--	25
JULY																
20...	0930	364	10.5	--	.02	--	--	.13	.11	.030	.000	.040	--	1.4	22	41
AUG.																
24...	0930	1030	14.5	--	--	--	--	--	--	--	--	--	--	1.5	83	75
SEP.																
20...	1845	1070	12.5	--	--	--	--	--	--	--	--	--	--	1.4	86	79

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	DIS-SOLVED NITRITE PLUS NITRATE INI (MG/L)	TOTAL NITRITE PLUS NITRATE INI (MG/L)	TOTAL NITRO-GEN INI (MG/L)	TOTAL KJEL-DAHL NITRO-GEN INI (MG/L)	DIS-SOLVED ORTHO PHOS-PHORUS IPI (MG/L)	TOTAL ORTHO PHOS-PHORUS IPI (MG/L)	TOTAL PHOS-PHORUS IPI (MG/L)	BIO-CHEM-ICAL OXYGEN DEMAND (MG/L)	HARD-NESS (CA,MG) (MG/L)	ALKA-LINITY AS CACO3 (MG/L)
OCT.													
19...	1715	1110	4.5	.89	--	.18	.13	.01	.00	.03	.7	74	79
NOV.													
15...	1530	930	5.5	--	--	--	--	--	--	--	.8	78	82
DEC.													
21...	0930	930	.5	--	--	--	--	--	--	--	1.6	66	71
JAN.													
17...	1530	1150	.0	.19	--	.42	.23	.03	.00	.06	1.1	72	79
FEB.													
22...	1015	760	3.0	--	--	--	--	--	--	--	1.5	73	83
MAR.													
21...	1845	344	8.0	--	--	--	--	--	--	--	1.6	72	79
APR.													
17...	1930	1760	8.0	.03	.04	.23	.19	.00	.01	.02	2.7	60	62
MAY													
20...	1430	5160	11.0	--	--	--	--	--	--	--	2.0	25	66
JUNE													
11...	1700	8200	16.0	--	--	--	--	--	--	--	1.0	44	45
JULY													
24...	1400	880	19.5	.08	.09	.24	.15	.08	.01	.03	1.5	78	104
AUG.													
29...	1100	466	16.5	.04	.08	.18	.30	.01	.02	.00	1.3	110	110

Appendix 7
USGS Data
Flathead River

FLATHEAD RIVER AT PERMA

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	DIS-SOLVED NITRATE (MG/L)	DIS-SOLVED NITRATE PLUS NITRITE (MG/L)	DIS-SOLVED AMMONIA NITROGEN (MG/L)	ORGANIC NITROGEN (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL NITROGEN (MG/L)	DIS-SOLVED ORTHO. PHOSPHORUS (MG/L)	TOTAL PHOSPHORUS (MG/L)	DIS-SOLVED ORTHO. PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	BIO-CHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS (CA+MG) (MG/L)	ALKALINITY AS CACO3 (MG/L)
OCT.																
13...	1200	7160	11.5	.21	.21	.02	.15	.38	.17	.060	.000	.080	.0	1.0	90	91
NOV.																
10...	1130	11100	4.5	--	--	--	--	--	--	--	--	--	--	1.3	--	88
DEC.																
15...	1230	13700	.5	--	--	--	--	--	--	--	--	--	--	1.2	88	88
JAN.																
07...	1230	13000	1.0	.02	.02	.06	.26	.34	.32	.010	.000	.020	1.0	1.2	--	87
FEB.																
10...	1230	13000	.0	--	--	--	--	--	--	--	--	--	--	1.1	--	87
MAR.																
15...	1200	14400	4.5	--	--	--	--	--	--	--	--	--	--	1.3	97	87
APR.																
17...	1200	20400	4.5	.00	.00	.08	.01	.09	.09	.010	.000	.020	.0	1.0	--	87
MAY																
03...	1100	18100	7.0	--	--	--	--	--	--	--	--	--	--	.8	--	85
JUNE																
09...	1200	50300	15.0	--	--	--	--	--	--	--	--	--	--	.9	82	86
JULY																
11...	1230	18800	17.5	--	.00	--	--	.11	.11	.020	.000	.020	--	2.0	87	75
AUG.																
17...	1330	8100	21.0	--	--	--	--	--	--	--	--	--	--	1.5	89	79
SEP.																
20...	1500	7160	14.0	--	--	--	--	--	--	--	--	--	--			

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	DIS-SOLVED NITRATE PLUS NITRITE (MG/L)	TOTAL NITRATE PLUS NITRATE (MG/L)	TOTAL NITROGEN (MG/L)	TOTAL WHOLE-DAHL NITROGEN (MG/L)	DIS-SOLVED ORTHO. PHOSPHORUS (MG/L)	TOTAL ORTHO PHOSPHORUS (MG/L)	TOTAL PHOSPHORUS (MG/L)	BIO-CHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS (CA+MG) (MG/L)	ALKALINITY AS CACO3 (MG/L)
OCT.													
20...	1130	7490	8.0	.04	--	.16	.06	.00	.00	.04	1.5	93	79
NOV.													
17...	1500	11700	4.0	--	--	--	--	--	--	--	1.4	87	90
DEC.													
21...	1330	7080	.0	--	--	--	--	--	--	--	.9	93	92
JAN.													
16...	1300	4500	2.5	.04	--	.50	.46	.01	.00	.05	.7	91	90
FEB.													
21...	1330	17700	2.5	--	--	--	--	--	--	--	.5	88	85
MAR.													
20...	1100	4100	6.0	--	--	--	--	--	--	--	1.1	91	90
APR.													
17...	1300	7700	8.0	.00	.00	.11	.11	.00	.00	.01	.7	90	87
MAY													
15...	1410	10700	15.0	--	--	--	--	--	--	--	.5	91	91
JUNE													
12...	1530	12300	14.0	--	--	--	--	--	--	--	.5	91	89
JULY													
17...	1700	11000	20.0	.00	.00	.14	.14	.00	.00	.00	.8	87	86
AUG.													
04...	1305	5300	22.5	.00	.01	.04	.03	.01	.00	.24	.2	85	88

Appendix 8

RESULTS OF ANALYSIS

UPPER CLARK FORK RIVER -- MONTANA (From EPA, 1975)

1974

Station No.	Date Yr/Mo/Day	Time Mtly	Temp. Cent.	pH SU	DO mg/l	Cond. µmho	Flow c.f.s.	Total-N mg/l	Total-P mg/l	Nitrate-N mg/l	NH_4-N mg/l	Or r
CF-1	74/8/19	0900	12.5	7.7	8.9	-	-	0.64	0.018	0.14	0.01	
	74/8/20	1130	13.9	8.0	9.1	850	-	0.52	0.035	0.22	0.03	
	74/8/21	1115	13.3	8.0	10.0	900	70	0.77	0.038	0.26	0.02	
	74/8/22	1145	15.0	7.8	9.8	915	-	0.50	0.031	0.14	0.04	
	74/8/23	0810	12.0	7.6	8.2	920	-	0.58	0.028	0.17	0.01	
CF-1A	74/8/19	0940	13.0	7.9	9.2	-	-	0.53	0.021	0.23	0.01	
	74/8/20	1115	12.8	8.0	8.8	830	-	0.60	0.040	0.22	0.04	
	74/8/21	1100	12.8	7.9	9.8	900	140	0.66	0.034	0.28	0.03	
	74/8/22	1115	14.4	7.8	9.9	860	-	0.54	0.030	0.21	0.03	
	74/8/23	0830	12.8	7.6	8.2	875	-	0.53	0.039	0.22	0.01	
CF-2	74/8/19	1015	14.0	8.0	10.6	-	-	0.53	0.080	0.10	0.02	
	74/8/20	1030	12.8	8.0	8.6	740	-	0.68	0.098	0.18	0.03	
	74/8/21	1035	12.2	7.9	10.3	850	150	0.70	0.088	0.26	0.03	
	74/8/22	1045	14.4	7.9	10.0	810	-	0.64	0.082	0.18	0.03	
	74/8/23	0850	13.3	7.7	8.6	825	-	0.69	0.090	0.17	<0.01	
LB-1	74/8/19	1040	13.0	8.1	10.3	-	-	0.16	0.042	0.01	0.02	
	74/8/20	1015	12.2	7.9	8.7	290	-	0.22	0.045	0.02	0.02	
	74/8/21	1020	12.2	7.8	9.6	320	80	0.20	0.047	0.01	0.02	
	74/8/22	1025	13.3	7.8	9.0	320	-	0.20	0.043	0.01	0.03	
	74/8/23	0910	12.8	7.7	8.7	320	-	0.42	0.043	0.02	0.01	
CF-3	74/8/19	1200	14.5	8.3	10.7	-	-	0.39	0.056	0.01	0.01	
	74/8/20	1000	12.8	7.9	8.6	650	-	0.52	0.073	0.04	0.02	
	74/8/21	1000	11.7	7.9	10.2	700	230*	0.57	0.080	0.12	0.02	
	74/8/22	1015	13.9	8.1	9.9	695	-	0.50	0.068	0.05	0.03	
	74/8/23	1420	17.0	8.1	11.0	700	-	0.44	0.060	0.04	0.01	
CF-4	74/8/19	1220	14.0	8.2	10.5	-	-	0.34	0.042	<0.01	0.01	
	74/8/20	0945	12.8	7.8	8.5	650	-	0.45	0.187	0.02	0.02	
	74/8/21	0940	11.7	7.9	10.4	690	240*	0.66	0.086	0.06	0.02	
	74/8/22	1000	13.3	8.0	9.5	690	-	0.50	0.065	0.02	0.03	
	74/8/23	1400	16.5	8.0	10.3	700	-	0.40	0.063	<0.01	0.01	
CF-5	74/8/19	1305	14.0	8.3	10.6	-	-	0.34	0.041	<0.01	0.01	
	74/8/20	0915	12.8	8.1	8.7	600	-	0.70	0.350	0.04	0.04	
	74/8/21	0915	11.7	8.0	9.6	650	260*	0.45	0.089	0.01	0.03	
	74/8/22	0940	13.3	8.2	9.2	655	-	0.42	0.068	0.01	0.03	
	74/8/23	1340	16.5	8.0	9.8	660	-	0.48	0.057	0.01	0.03	
CF-6	74/8/19	1340	14.0	8.2	9.8	-	-	0.28	0.040	<0.01	0.01	
	74/8/20	0930	12.0	7.9	8.5	600	-	0.36	0.070	<0.01	0.01	
	74/8/21	0925	12.0	8.4	9.1	640	270	0.40	0.073	<0.01	0.02	
	74/8/22	0920	13.9	8.1	8.8	680	-	0.49	0.069	<0.01	0.02	
	74/8/23	1320	16.0	7.8	9.5	660	-	1.01	0.062	0.01	0.03	
FC-1	74/8/19	1440	13.5	8.3	9.9	-	-	0.32	0.074	0.02	0.01	
	74/8/20	1005	11.0	7.8	9.8	520	-	0.46	0.096	0.08	0.03	
	74/8/21	1025	10.5	8.4	10.5	480	90	0.30	0.088	0.08	0.02	
	74/8/22	0950	11.0	8.2	-	500	-	0.32	0.082	0.07	0.03	
	74/8/23	1240	14.4	7.6	9.6	490	-	0.42	0.086	0.06	0.01	
CF-7	74/8/19	1505	14.5	8.1	10.0	-	-	0.36	0.047	<0.01	0.01	
	74/8/20	1030	11.5	8.0	8.8	670	-	0.40	0.067	0.01	0.02	
	74/8/21	1000	10.5	8.2	9.6	620	400	0.42	0.073	<0.01	0.01	
	74/8/22	0920	12.5	8.1	-	650	-	0.38	0.083	0.02	0.03	
	74/8/23	1255	15.0	7.4	9.6	680	-	0.44	0.072	0.01	0.01	
CF-8	74/8/19	1650	16.0	8.5	10.6	-	-	0.30	0.035	<0.01	0.01	
	74/8/20	1225	13.0	8.1	9.7	660	-	0.32	0.039	0.01	0.02	
	74/8/21	1240	15.0	8.6	10.5	660	450*	0.34	0.050	<0.01	0.01	
	74/8/22	1130	15.0	8.4	-	620	-	0.28	0.046	<0.01	0.02	
	74/8/23	1130	15.6	7.7	9.4	700	-	0.46	0.046	<0.01	<0.01	
MC-1	74/8/19	1715	14.0	8.4	9.7	-	-	0.10	0.015	<0.01	0.01	
	74/8/20	1250	11.0	7.1	10.5	125	-	0.12	0.015	<0.01	0.01	
	74/8/21	1315	13.0	8.2	10.7	155	420	0.14	0.017	<0.01	0.03	
	74/8/22	1200	12.0	8.3	-	145	-	0.32	0.020	<0.01	0.03	
	74/8/23	1145	13.3	7.5	10.0	155	-	0.17	0.027	<0.01	<0.01	
CF-9	74/8/19	1615	15.0	8.5	10.0	-	-	0.12	0.022	<0.01	0.01	
	74/8/20	1135	12.0	7.6	9.5	410	-	0.18	0.026	<0.01	0.02	
	74/8/21	1200	13.5	8.4	10.3	420	870*	0.18	0.028	<0.01	0.02	
	74/8/22	1050	13.0	8.3	-	425	-	0.20	0.030	<0.01	0.03	
	74/8/23	1100	14.4	7.5	9.5	460	-	0.47	0.032	<0.01	0.01	

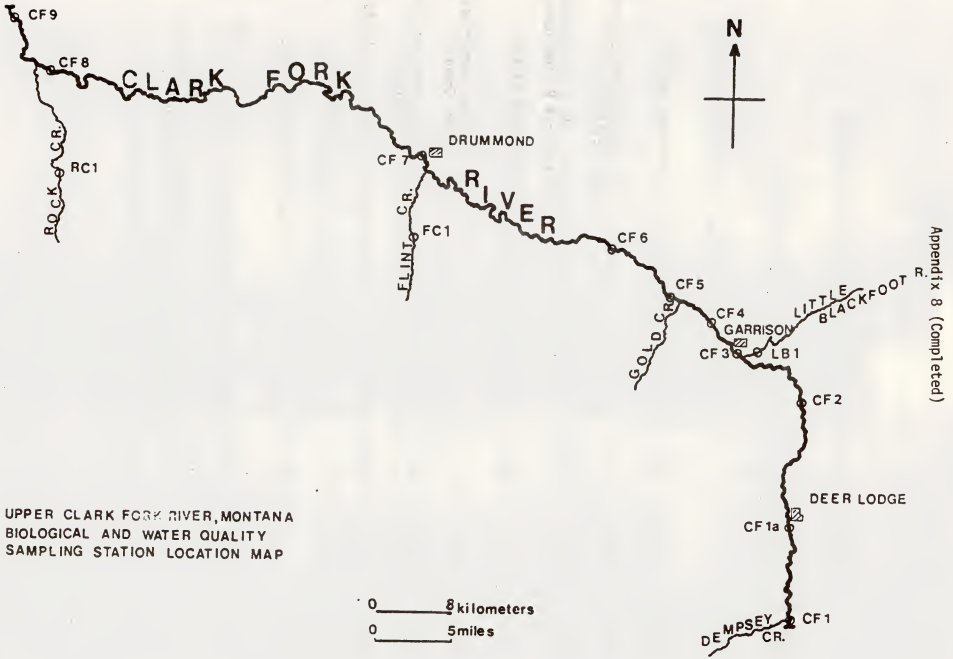
Note: * signifies an estimated measurement

Appendix 8 (Continued)

UPPER CLARK FORK RIVER STUDY

BIOLOGICAL AND WATER QUALITY SAMPLING STATION LOCATIONS

Station No.	Approx. Dist. From Dempsey Creek		Description
	Miles	km	
CF-1	0	0	Clark Fork River upstream of its confluence with Dempsey Creek
CF-1A	6 1/4	10.1	Clark Fork River upstream of Deerlodge and the Montana Hwy. 10A bridge
CF-2	15 5/8	25.2	Clark Fork River downstream of Deerlodge and upstream of the bridge to the Rock Creek Cattle Co.
LB-1	22 7/8	36.9	Little Blackfoot River upstream of the U.S. 90, Mont. St. 10 bridge, 1/2 mi. from Clark Fork R. confluence
CF-3	23 1/8	37.2	Clark Fork River at Garrison downstream of the service road bridge
CF-4	25 5/8	41.3	Clark Fork River downstream of Garrison where river nears the service road at Warm Springs Creek
CF-5	28 3/4	46.3	Clark Fork River upstream of the Gold Creek exit bridge and downstream of the Gold Creek confluence
CF-6	35	56.4	Clark Fork River downstream of the Jens exit bridge
FC-1	52 1/4	84.1	Flint Creek downstream of the bridge on the improved dirt road to the cemetery
CF-7	53 1/8	85.5	Clark Fork River at Drummond downstream of the railroad bridge
CF-8	86 7/8	139.9	Clark Fork River upstream of its confluence with Rock Creek at the old Rock Creek Bridge
RC-1	87 7/8	141.5	Rock Creek where it first approaches the improved dirt road about 3 miles up the canyon
CF-9	94 3/8	151.9	Clark Fork River upstream of Clinton at the Schwartz Creek bridge



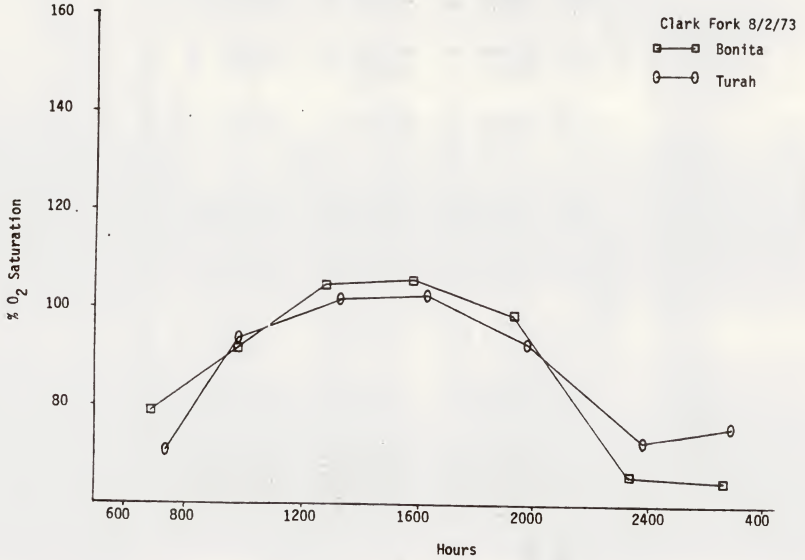
UPPER CLARK FORK RIVER, MONTANA
BIOLOGICAL AND WATER QUALITY
SAMPLING STATION LOCATION MAP

Appendix 9.1 Ambient Air Temperature and Precipitation Conditions at Reporting Weather Stations During the Diel Dissolved Oxygen Sampling Periods in 1973, 1976 and 1977 (Temp. in °F, Precip. in inches).

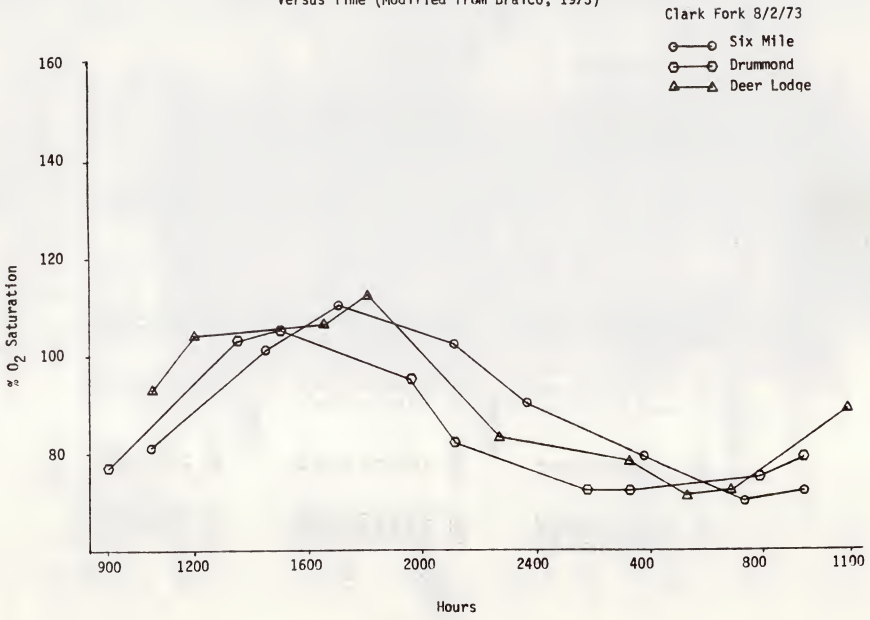
		DAILY CONDITIONS				MONTHLY CONDITIONS				
STATION	DATE	AVE. TEMP.	AVE. MAX.	AVE. MIN.	GENERAL COND.	MONTH	AVE. TEMP.	AVE. MAX.	AVE. MIN.	TOTAL PRECIP.
Deer Lodge	8/2-3/73	72.3	89.0	55.5	Clear	8/73	63.5	82.5	44.5	0.67
	7/20-21/76	62.0	80.0	44.0	Rain	7/76	62.5	82.1	42.8	1.27
	7/20-21/77	65.5	85.0	46.0	Rain	7/77	60.5	78.4	42.5	1.68
	8/3-4/77	66.8	86.0	47.5	Cldy.	8/77	59.8	78.3	41.2	0.89
	8/18-19/77	67.0	90.0	44.0	Clear					
	9/13-14/77	57.0	81.0	33.0	Clear	9/77	51.7	68.3	35.1	2.71
Drummond	8/2-3/78	68.5	90.5	46.5	Clear	8/73	64.4	84.8	44.0	0.48
	7/20-21/76	63.5	78.5	48.5	Rain	7/76	66.0	85.0	46.9	0.74
	7/20-21/77	65.0	83.0	47.0	Rain	7/77	63.1	80.9	45.2	1.15
	8/3-4/77	70.0	88.5	51.5	Cldy.	8/77	62.7	81.1	44.2	0.84
	8/18-19/77	68.3	93.0	43.5	Clear					
	9/13-14/77	56.8	80.5	33.0	Clear	9/77	54.1	70.0	38.1	1.27
Missoula	8/2-3/73	73.3	93.0	53.5	Clear	8/73	67.4	85.2	49.5	0.41
	7/20-21/76	67.8	82.5	53.0	Cldy.	7/76	66.8	83.7	49.9	1.20
	7/20-21/77	69.0	89.0	49.0	Rain	7/77	65.8	81.5	50.1	0.72
	8/3-4/77	71.8	84.5	59.0	Cldy.	8/77	67.6	83.3	51.9	1.28
	8/18-19/77	75.0	97.0	53.0	Clear					
	9/13-14/77	59.5	79.5	39.5	Clear	9/77	54.6	67.6	41.5	1.67

1 U.S. Dept. of Commerce, National Weather Service Records

Appendix 10. Diel Dissolved Oxygen As Percent Saturation Versus Time (Modified from Braico, 1973)



Appendix 11. Diel Dissolved Oxygen As Percent Saturation Versus Time (Modified from Braico, 1973)



APPENDIX 12. Time, Temperature, Dissolved Oxygen and Percent Saturation for 5 Stations on the Clark Fork River 8/2-3/73 (From Braico 1973)

DEER LODGE

	Time	Temp.	D.O.	% Sat.
8/2	1030	61	7.8	93
	1200	63	8.4	104
	1630	66	8.4	106
	1800	68	8.7	112
	2230	64	6.7	83
8/3	0030	64	6.3	78
	0500	61	5.9	71
	0630	61	6.0	72
	1030	61	7.5	89

TURAH

	Time	Temp.	D.O.	% Sat.
8/2	0730	61	6.2	71
	1000	64	8.1	96
	1330	68	8.3	102
	1630	72	8.0	103
	2000	69	7.5	93
8/3	0015	67	6.0	73
	0300	64	6.4	76

DRUMMOND

	Time	Temp.	D.O.	% Sat.
8/2	0900	52	7.3	77
	1330	68	8.2	103
	1500	70	8.2	105
	1930	72	7.2	95
	2100	70	6.4	82
8/3	0130	63	6.0	72
	0300	63	6.0	72
	0730	59	6.6	75
	0900	59	7.0	79

HUSON

	Time	Temp.	D.O.	% Sat.
8/2	1030	57	7.5	81
	1430	61	8.8	101
	1700	64	9.3	110
	2100	63	8.8	102
	2330	63	7.8	90
8/3	0330	61	7.0	79
	0700	57	6.5	70
	0900	57	6.7	72

BONITA

	Time	Temp.	D.O.	% Sat.
8/2	0700	63	6.7	79
	1000	64	7.7	92
	1300	71	9.0	115
	1600	76	8.7	116
	1930	76	7.4	99
	2230	71	5.2	66
8/3	0245	67	5.3	65

Appendix 13. Selected Streamflow Data (Cubic Feet Per Second)
During Diel Dissolved Oxygen Sampling Periods
Actual Flows

STATION NAME	USGS STATION NUMBER	MEAN FLOW FOR SAMPLING DATES 8/2-3/73	7/20-21/76	7/20-21/77	8/3-4/77	8/18-19/77	9/13-14/77
Clark Fork at Drummond	12331600	89	1120	215	133	108	275
Rock Creek near Clinton	12334510	226	1080	308	217	119	162
Blackfoot River near Bonner	12340000	502	1805	524	429	404	390
Clark Fork above Missoula	12340500	905	4175	1155	888	680	845
Clark Fork below Missoula	12353000	1285	7405	1680	1550	1120	1380

Measured, Calculated, Estimated or Gauged Flows for Selected Sampling Stations

STATION NAME	Flow During Sampling Dates 8/2-3/73	7/20-21/76	7/20-21/77	8/3-4/77	8/18-19/77	9/13-14/77
Deer Lodge[1]	50	615	120	75*	60*	150
Gold Creek[2]	90	1120	215	125*	110*	275
Bonita[3]	180	1290	320	225*	145*	290
Turah[4]	405	2370	630	460	275	450
Missoula[5]	905	4175	1155	890	680	845
Huson[6]	1285	7505	1680	1550	1120	1380

1 Fish and Game Measurement* or calculated as 0.55 x Drummond flow
2 Fish and Game Measurement* or estimated to be equal to Drummond flow
3 Fish and Game Measurement* or estimated to be equal to above Missoula - (Blackfoot & Rock Creek) flows
4 Estimated to be equal to above Missoula - Blackfoot flow
5 Gauged (Above Missoula)
6 Gauged (Below Missoula)

Appendix 14. Maximum and Minimum Stream Temperatures Recorded at the Bonita (above Rock Creek) Station on the Clark Fork River During the Summer of 1977. Note That From July 7 Through August 23 the Average Temperature Exceeded 62.5°F (Montana Department of Fish and Game, 1977)

Day	July		Aug.		Sept.	
	Min.	Max.	Min.	Max.	Min.	Max.
1	60.0	69.5	61.5	72.5	54.0	63.0
2	57.5	70.0	63.0	74.5	55.5	62.0
3	55.5	61.0	64.0	73.5	57.0	62.0
4	55.0	65.0	64.0	75.0	57.0	66.0
5	56.0	69.0	61.0	70.0	60.5	67.0
6	56.0	64.5	60.0	71.0	59.5	68.0
7	55.0	70.5	64.0	72.0	58.5	62.0
8	61.0	73.0	63.5	73.5	53.0	61.5
9	63.0	69.0	63.0	73.0	55.5	61.5
10	62.0	68.0	61.5	72.0	54.0	63.0
11	60.0	70.0	61.0	73.0	55.0	63.0
12	62.5	73.5	62.0	74.0	54.5	62.5
13	60.0	66.5	64.0	75.0	55.0	64.5
14	59.0	71.5	64.0	71.0	55.0	62.5
15	62.0	73.5	61.0	70.0	55.0	59.0
16	63.5	72.5	61.5	73.5	54.5	58.0
17	64.0	69.0	63.0	74.0	52.0	55.0
18	62.5	65.5	63.5	75.0	50.0	56.0
19	63.0	71.0	64.0	75.0	52.0	56.5
20	62.5	72.0	64.0	73.5	53.0	56.5
21	64.0	71.0	63.0	74.0		
22	63.5	75.5	60.5	69.5		
23	67.0	77.5	60.0	69.5		
24	67.5	71.0	58.5	64.5		
25	64.5	68.0	58.5	63.5		
26	63.0	68.5	56.5	61.0		
27	62.0	74.0	56.0	61.0		
28	64.0	72.5	56.5	59.5		
29	61.5	70.0	56.0	59.0		
30	60.0	71.0	52.0	55.5		
31	—	—	51.5	60.0		